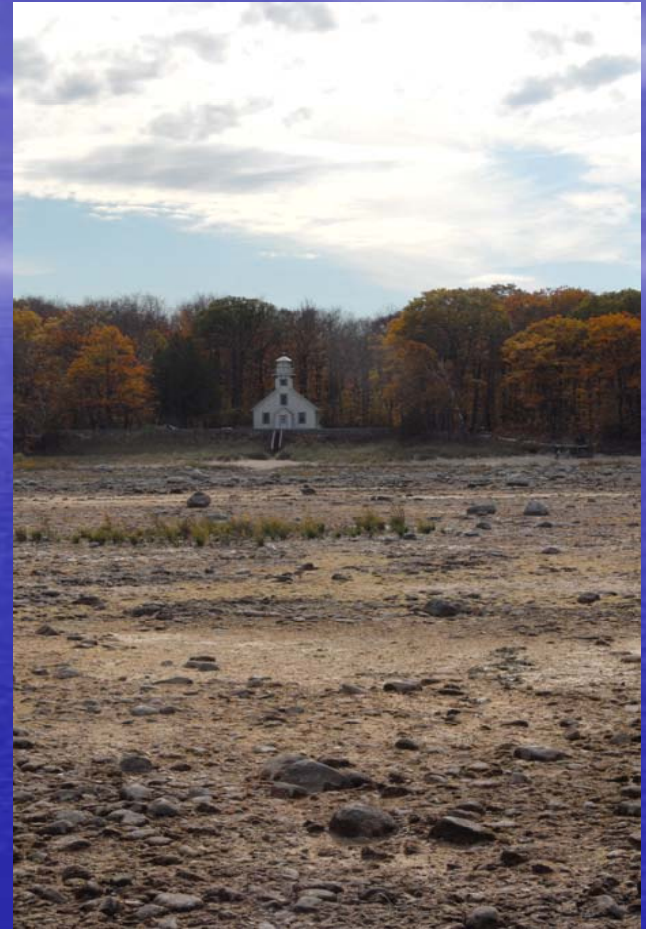


The Rise and the Fall



Of The Great Lakes

*Presented by Cynthia Sellinger with generous contributions from:
Craig Stow, Jia Wang, and Xuezhi Bai*

Great Lakes Shipping Industry

- 1270 Mile Transportation Route
- Commercial Shipping—2 Billion Tons--\$300 billion.
- 60% of seaway traffic travels to and from overseas ports (Europe, the Middle East and Africa).
- 80% of cargoes shipped each year include iron ore, coal, grain, and steel



Lake Carriers that transport iron ore, coal, grain and other raw cargoes are forced into “light-loading”, carrying 5 percent to 10 percent less goods, sending prices higher.

Marinas

- Billions of Dollars in Recreational and Sports Fishing



*Since the Year 2000
Marinas spent
Millions to dredge
boat slips, channels,
and harbors along
the Great Lakes
Coasts*

Energy Industry

Several Nuclear Power plants around the Great Lakes spent Millions dredging in order to have their cooling pipes once-again be able to draw in the thousands of gallons of water needed to cool the plant.



At least two New York Hydropower plants could not meet the power supply to hundreds of businesses due to the lack of water to turn the turbines, sending businesses elsewhere for higher price electricity.

2007 Impacts

- **Minnesota Public Radio—Bob Kelleher—27 April 2007--“Port of Duluth—there are places where the harbor is just drying up”**
 - On a 1000 footer, one inch of draft = 250 – 267 tons of coal
 - Lake Superior dropped 24 inches since 1997~ 6,204 tons
 - Less profit for shippers
 - Higher cost for coal generated electric power
 - Higher cost for steel made from Minnesota taconite
- **USA Today—Dennis Cauchon—13 July 2007**
 - Wetlands drying up—Wild Rice Gone
 - Power plants run half capacity –Edison Sault Electric Power
 - Boaters struggle to find a place to dock
 - Cargo ships light load by 5% cost \$1M per year per ship
- **Associated Press—John Fletcher—28 July 2007**
 - Boats can't reach many mooring sites
 - Marina operators are begging U.S. Army Corp of Engineers to dredge shallow harbors
 - Ferry service between Grand Portage, Minnesota and Isle Royale National Park scaled back—can't dock.
- **Detroit News—Jim Lynch—15 August 2007**
 - Edison Sault Electric Company operating at 25 percent of Capacity
 - Customers will see a big spike in their electric bills after the first of the year
- **Muskegon Chronicle– Ship Frees itself at Mouth of Muskegon Channel—22 August 2007**
 - A 1,000-foot freighter headed for Consumer Energy's B.C. Cobb plant
 - *The Indiana Harbor*, which was to deliver coal to the power plant, appeared to have run hard aground about 3 p.m. It is stuck less than 100 yards outside the outer pier head of Muskegon harbor.



1000-footer ran aground in Muskegon



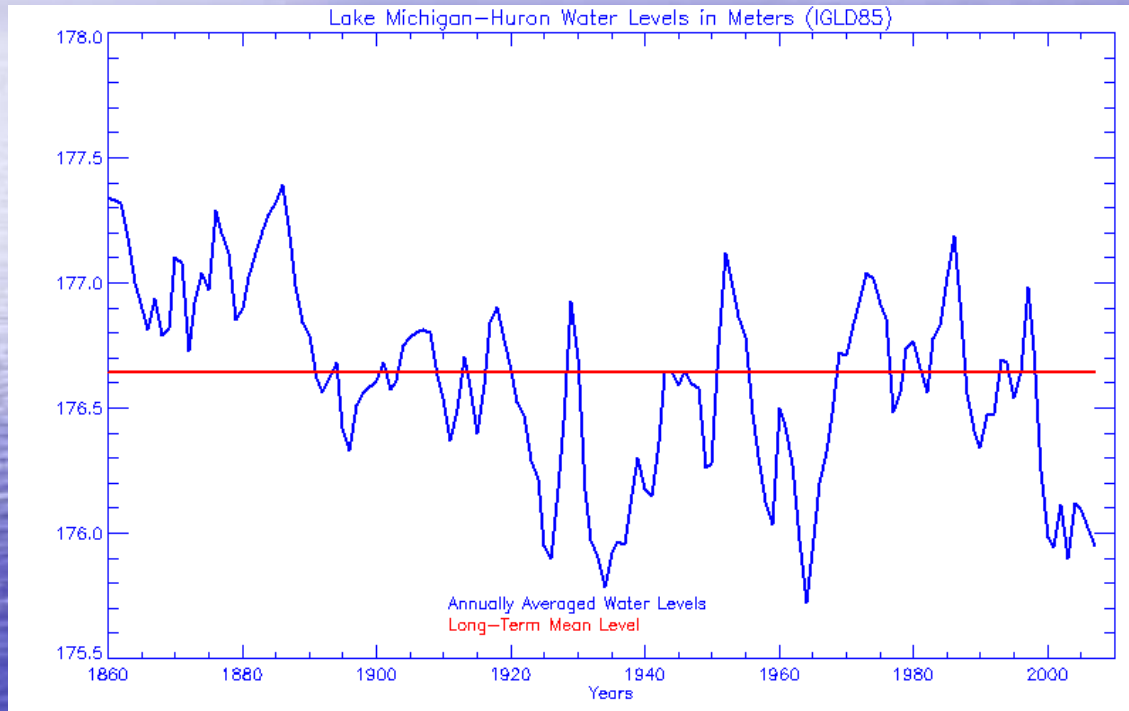
Thousand-Footer Runs Aground in Muskegon Channel—22 August 2007

LMFS1 Wed Aug 22 14:00:01 2007



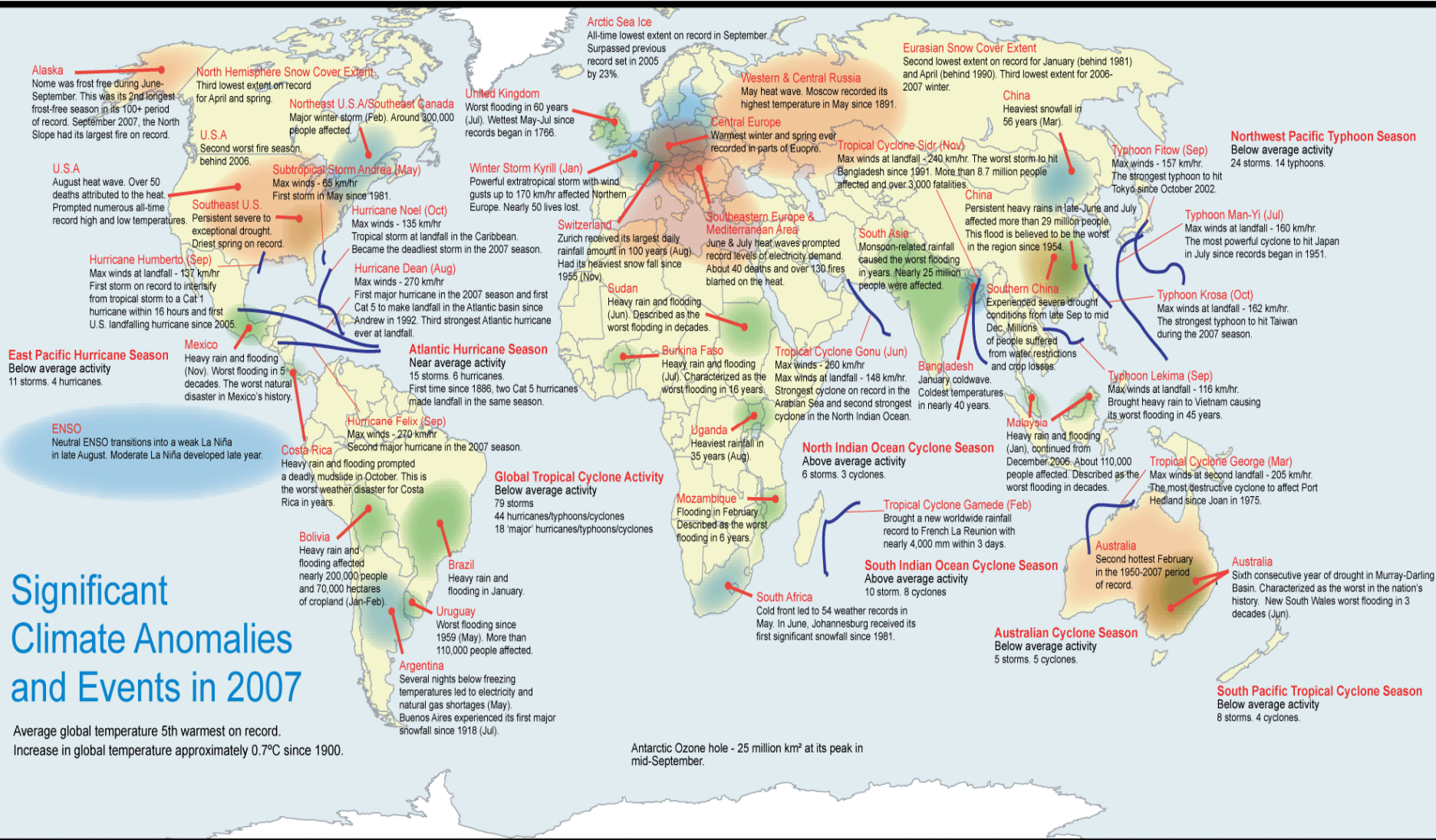
Lakes Michigan-Huron Hydrograph

Old Mission Point—
October 2007



Significant Climate Anomalies and Events in 2007

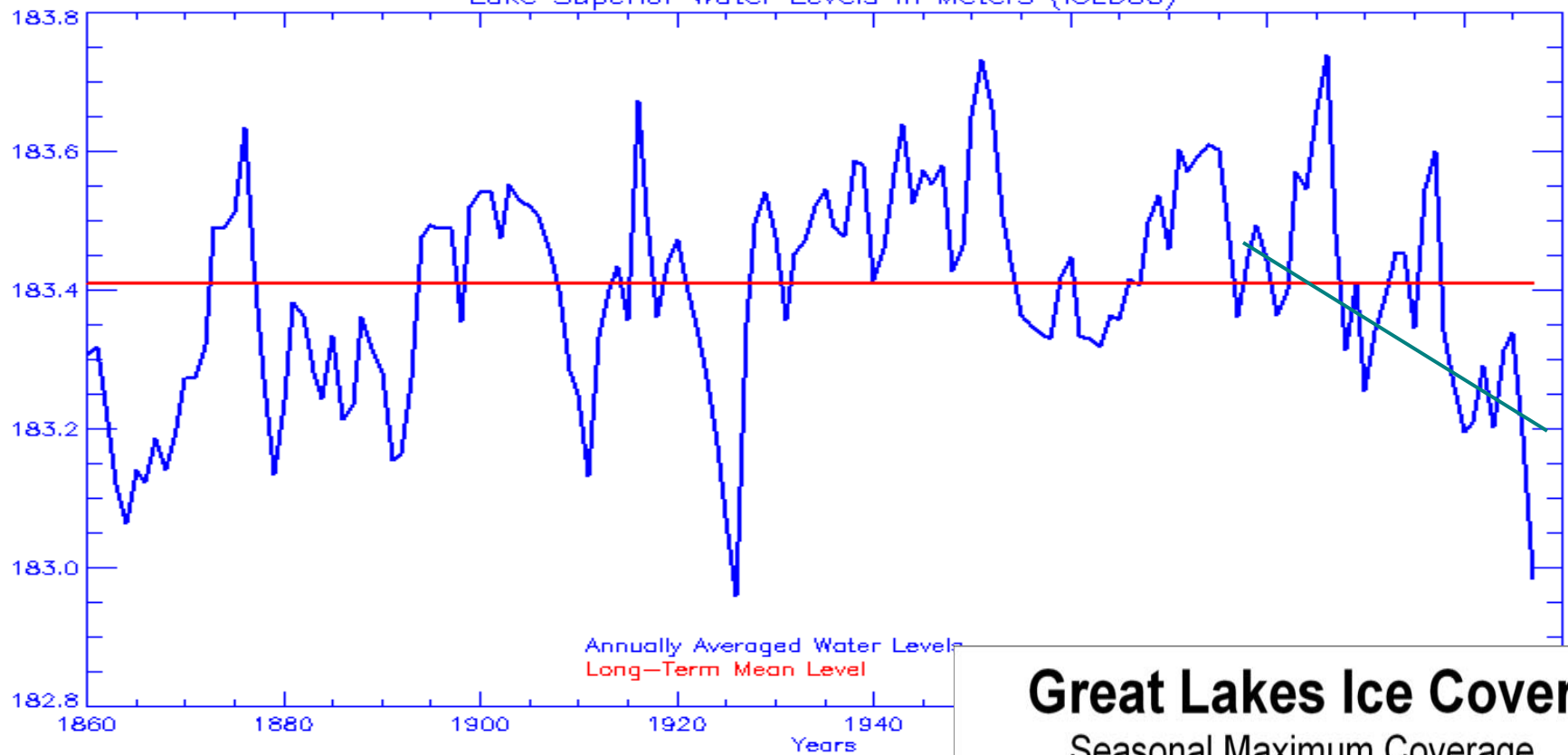
Average global temperature 5th warmest on record.
Increase in global temperature approximately 0.7°C since 1900.



NOAA's National Climatic Data Center

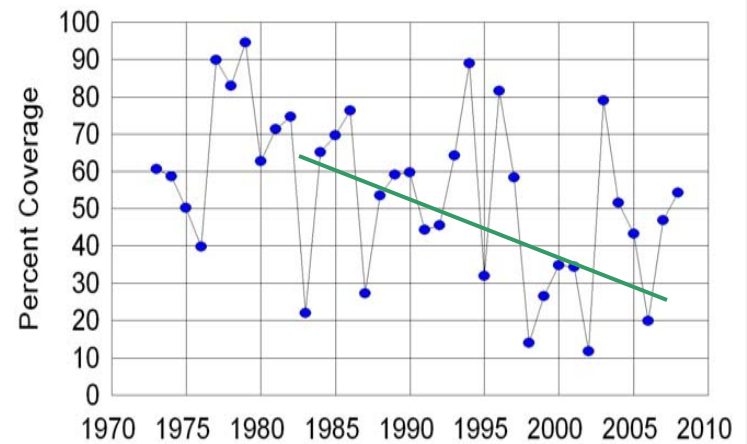
- 5th warmest global temperature on record (separately; warmest → Land surface temperature; 9th warmest → ocean temperature)
- 0.7°C GLOBAL temperature increase since 1900 (most rapid since 1976 [3 times faster than the century-scale trend])
- August Heat wave—over 50 deaths nationally
- Lake Superior reaches a record low in September 2007

Lake Superior Water Levels in Meters (IGLD85)

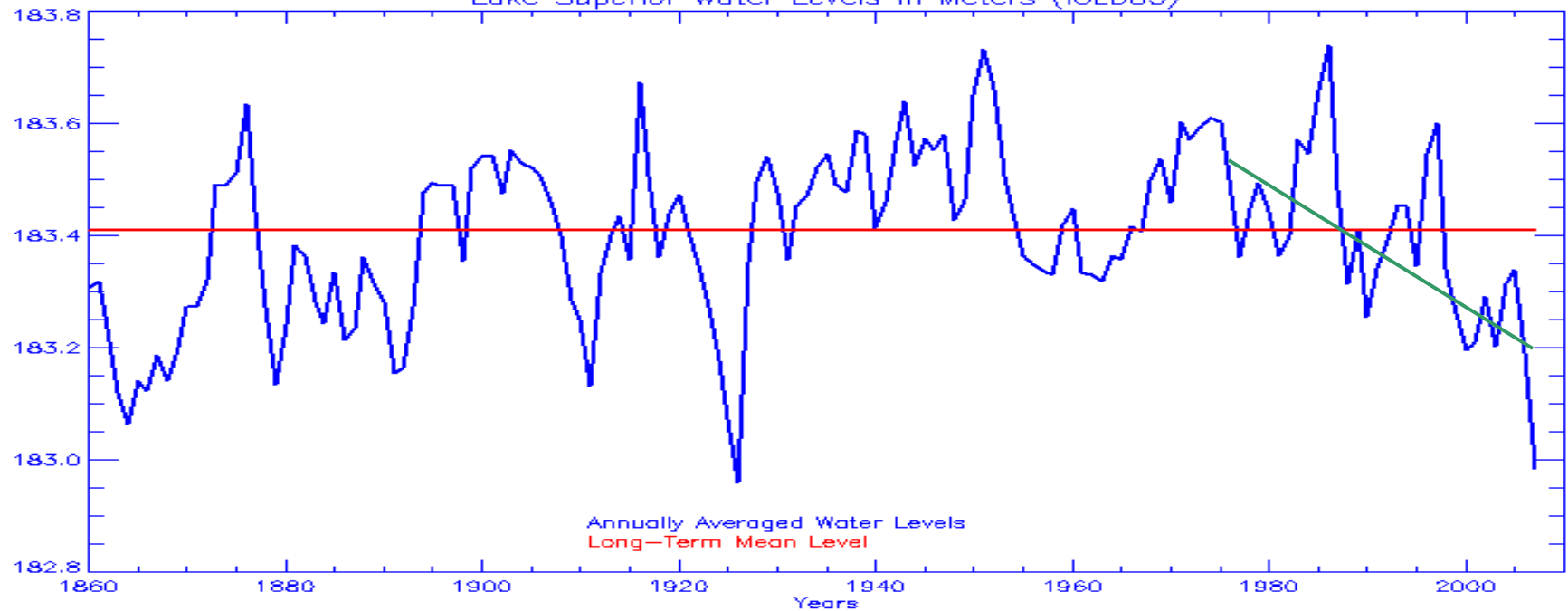


Great Lakes Ice Cover

Seasonal Maximum Coverage



Lake Superior Water Levels in Meters (IGLD85)

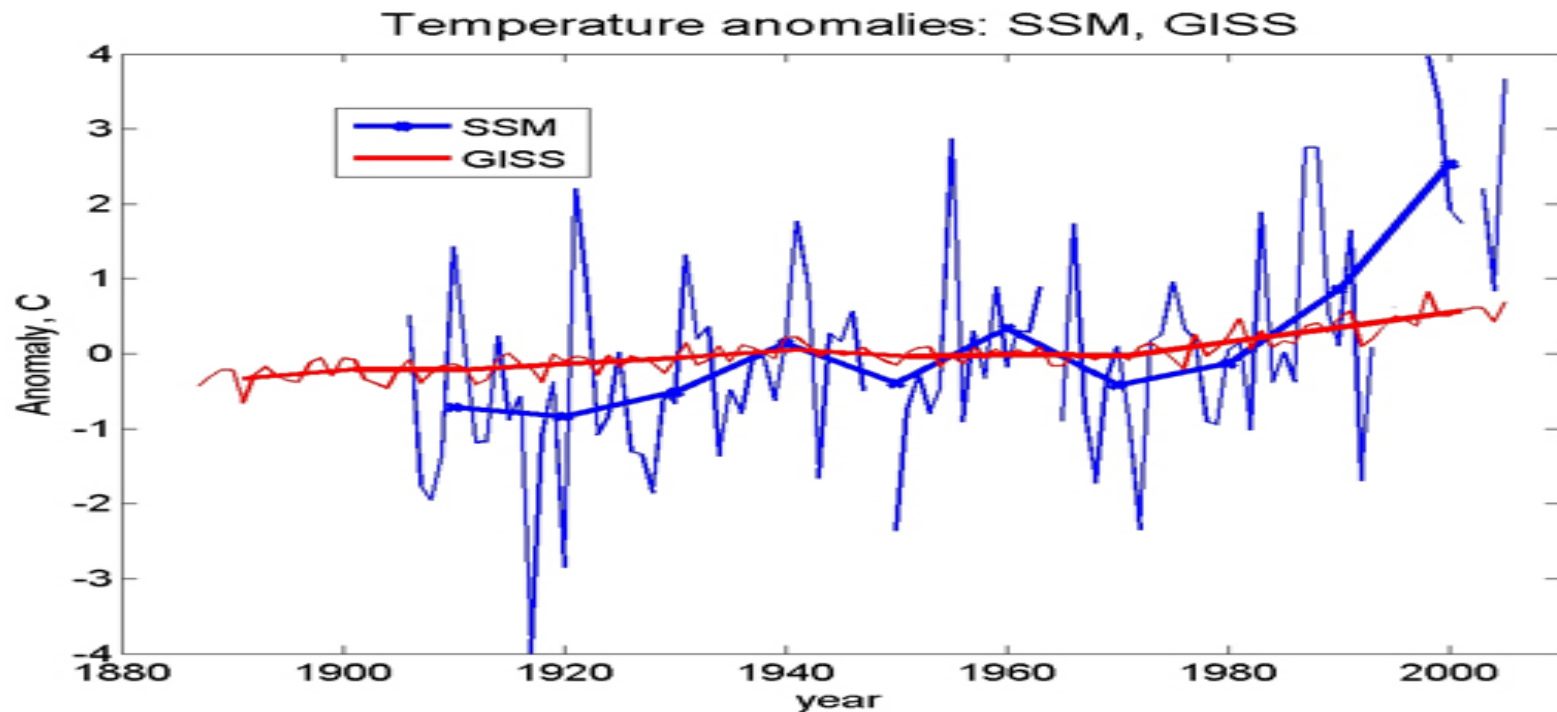


Tair-Tw ~ Evap

Jay Austin:

SSM-- Sault
Ste Marie Tw

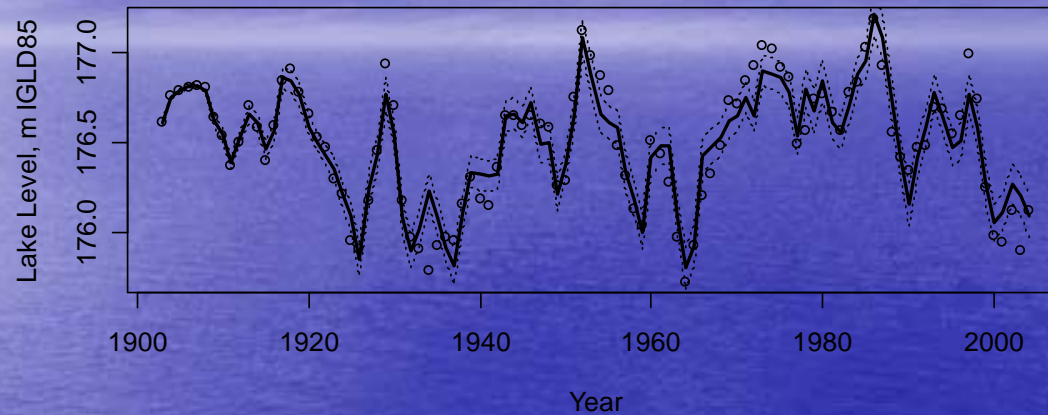
GISS-- Global
Tsfc



Dynamic Linear Models (A Bayesian Technique)

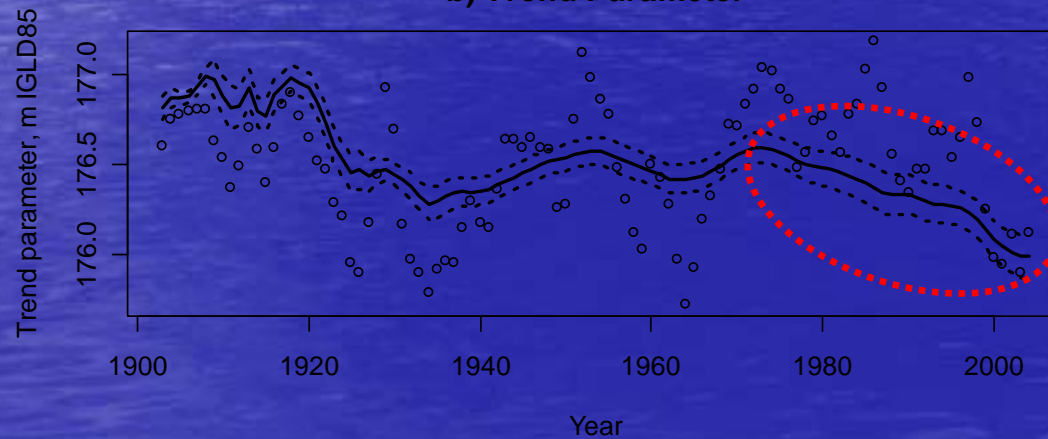
Water Level Surface at Harbor Beach

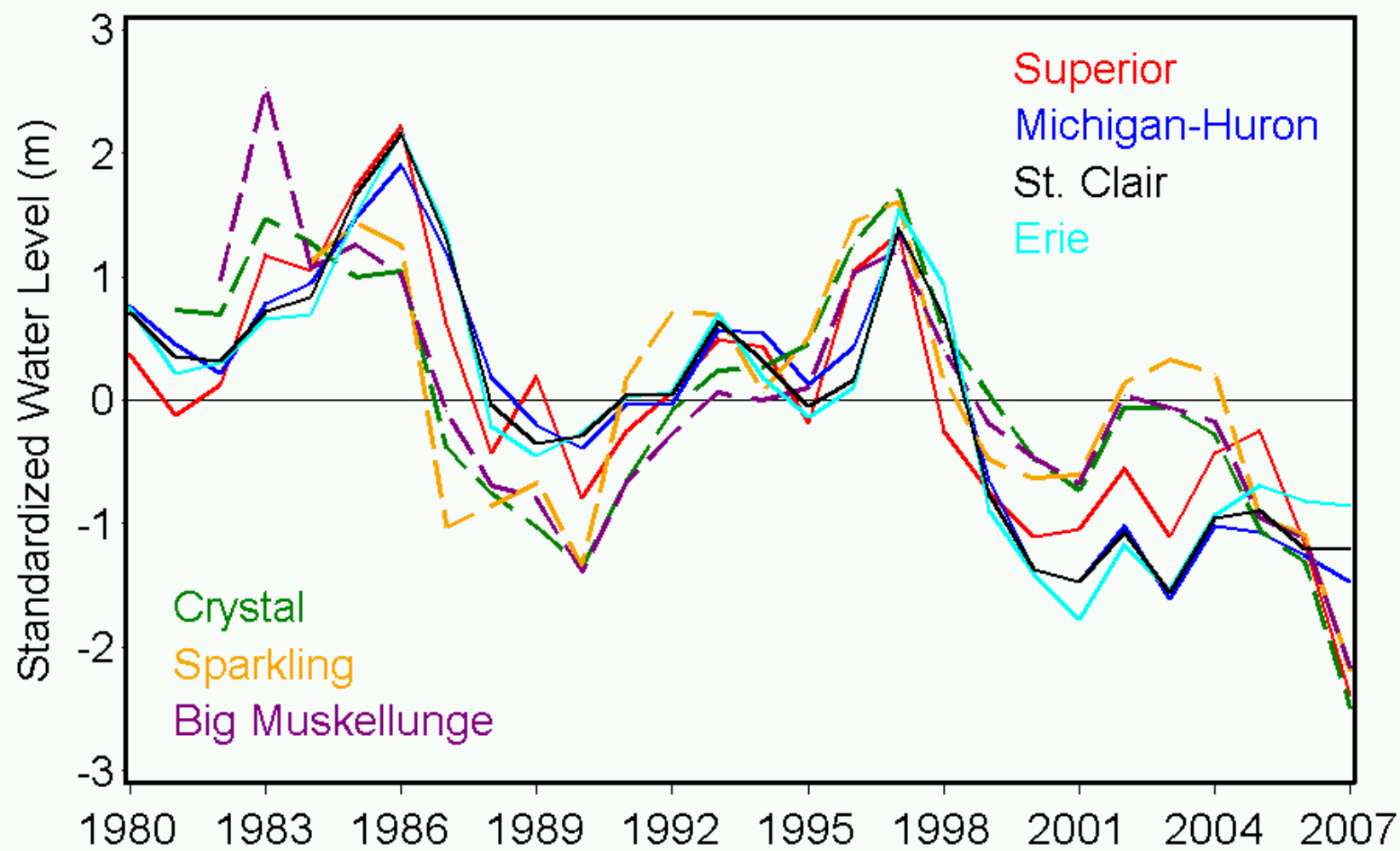
a) Fitted values



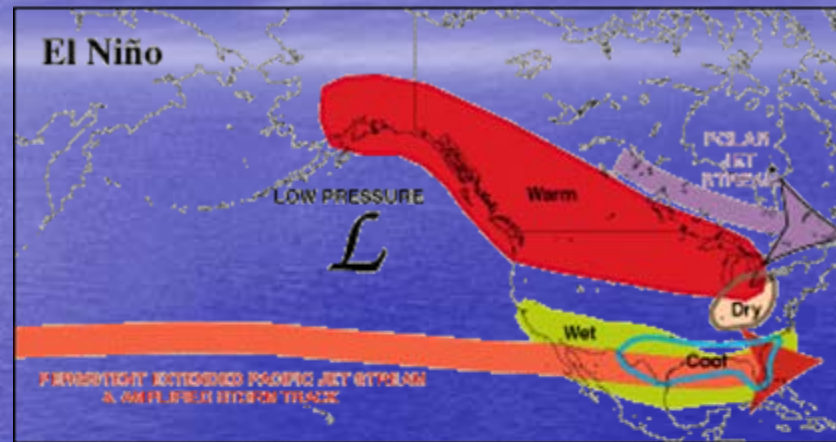
$R^2 = 0.89$

b) Trend Parameter



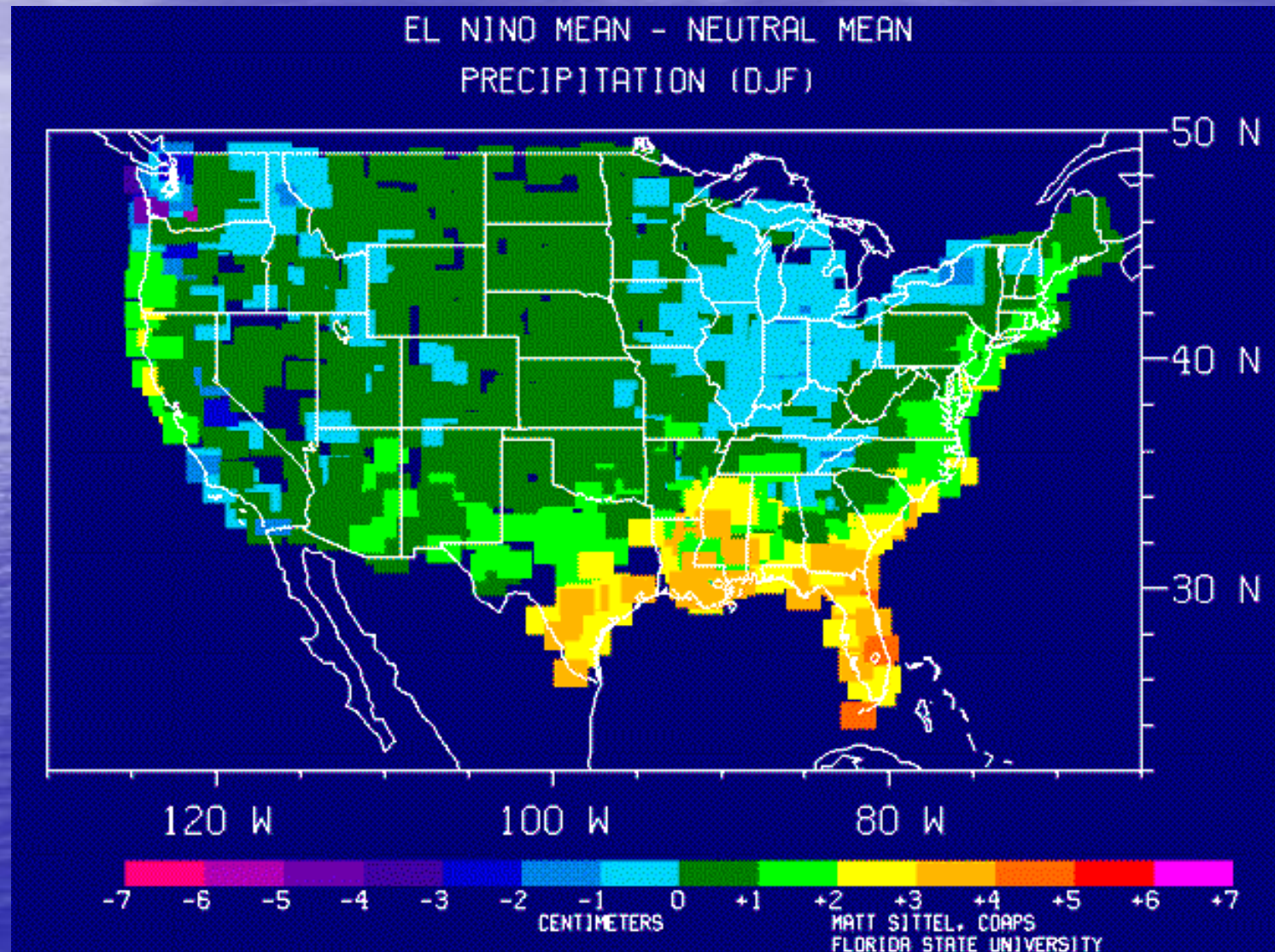


The Jet Stream

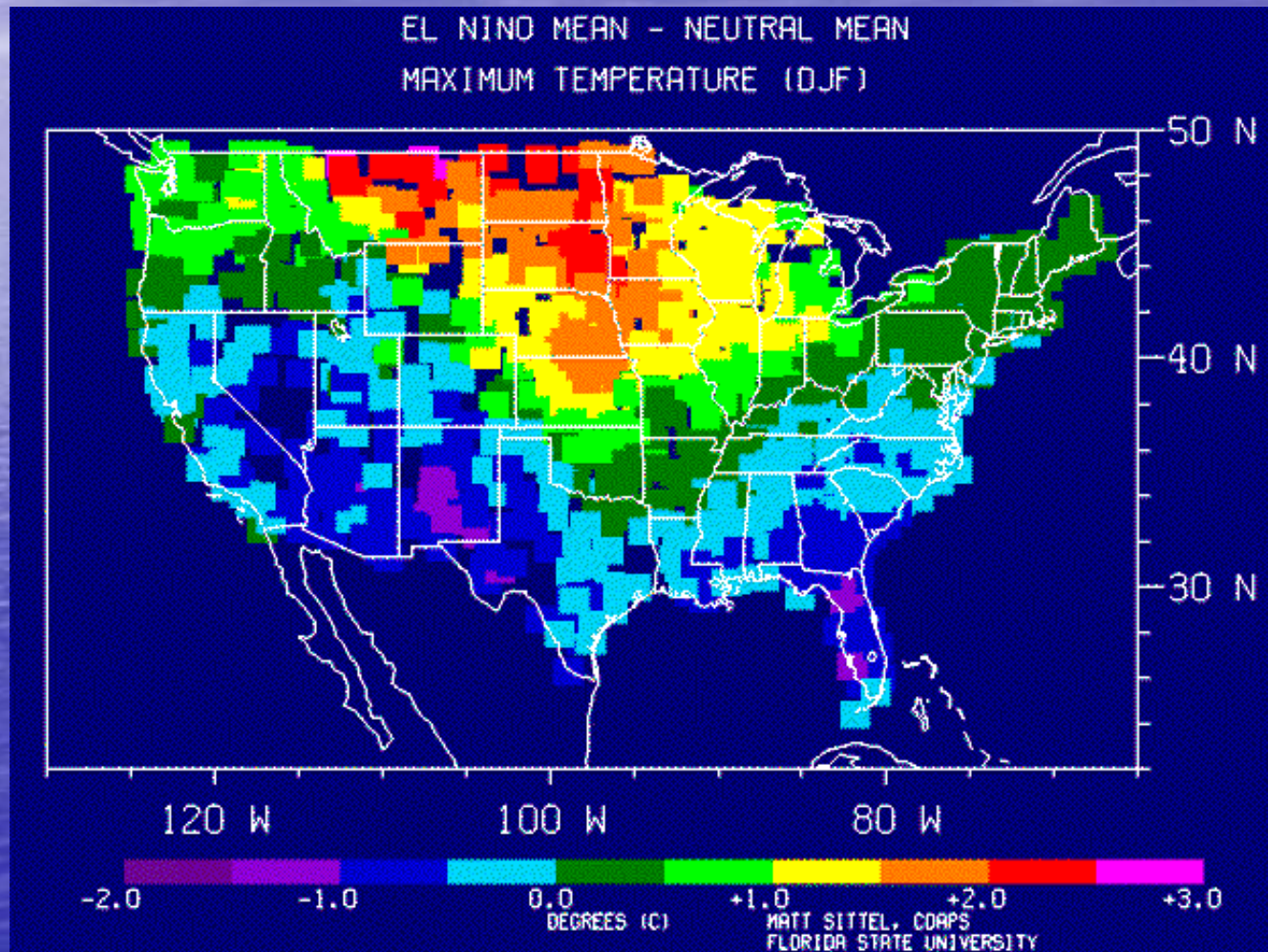


Climate Prediction Center/NCEP/NWS

United States Winter Precipitation Pattern During El Nino

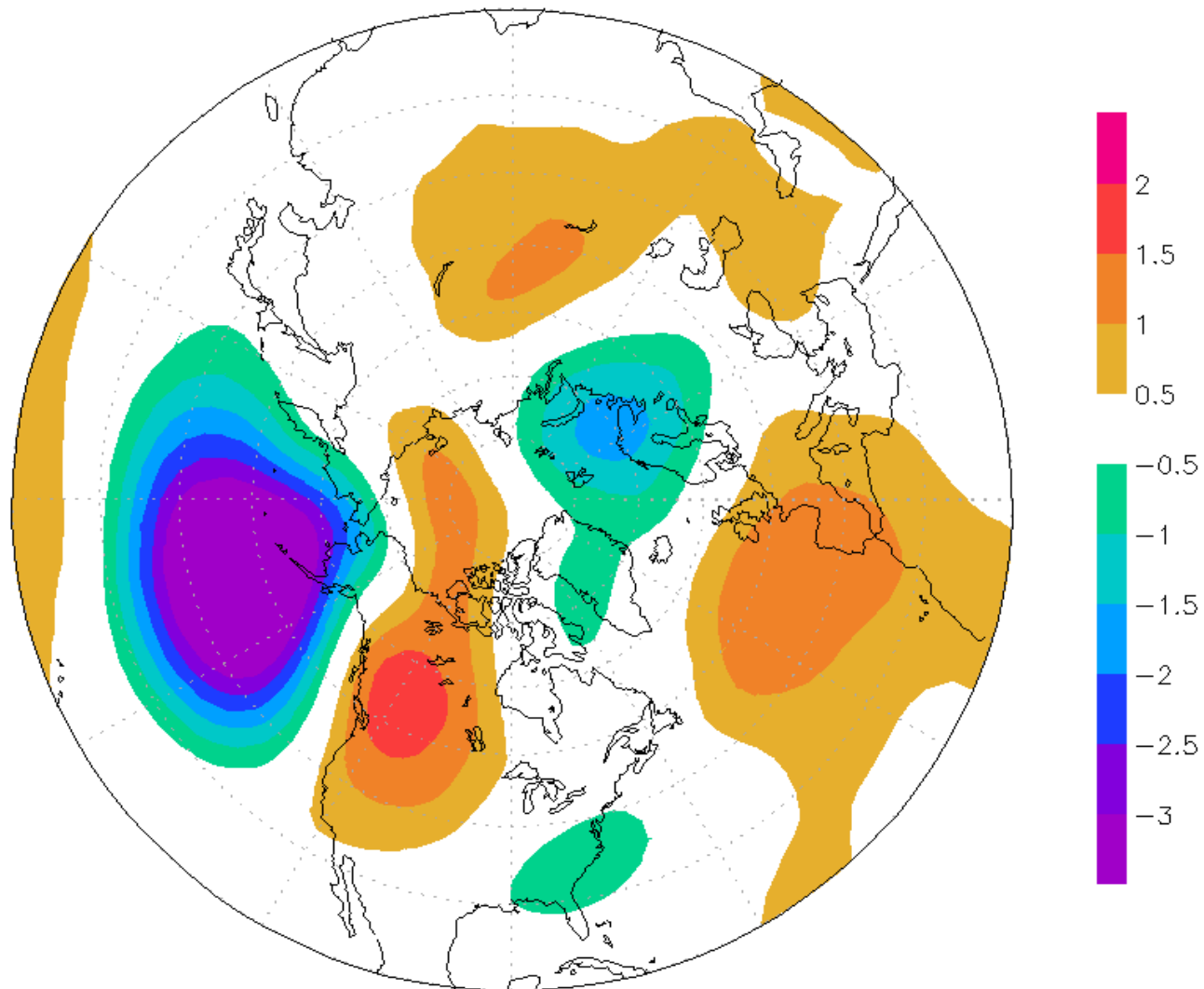


United States Winter Temperature Patterns During El Nino

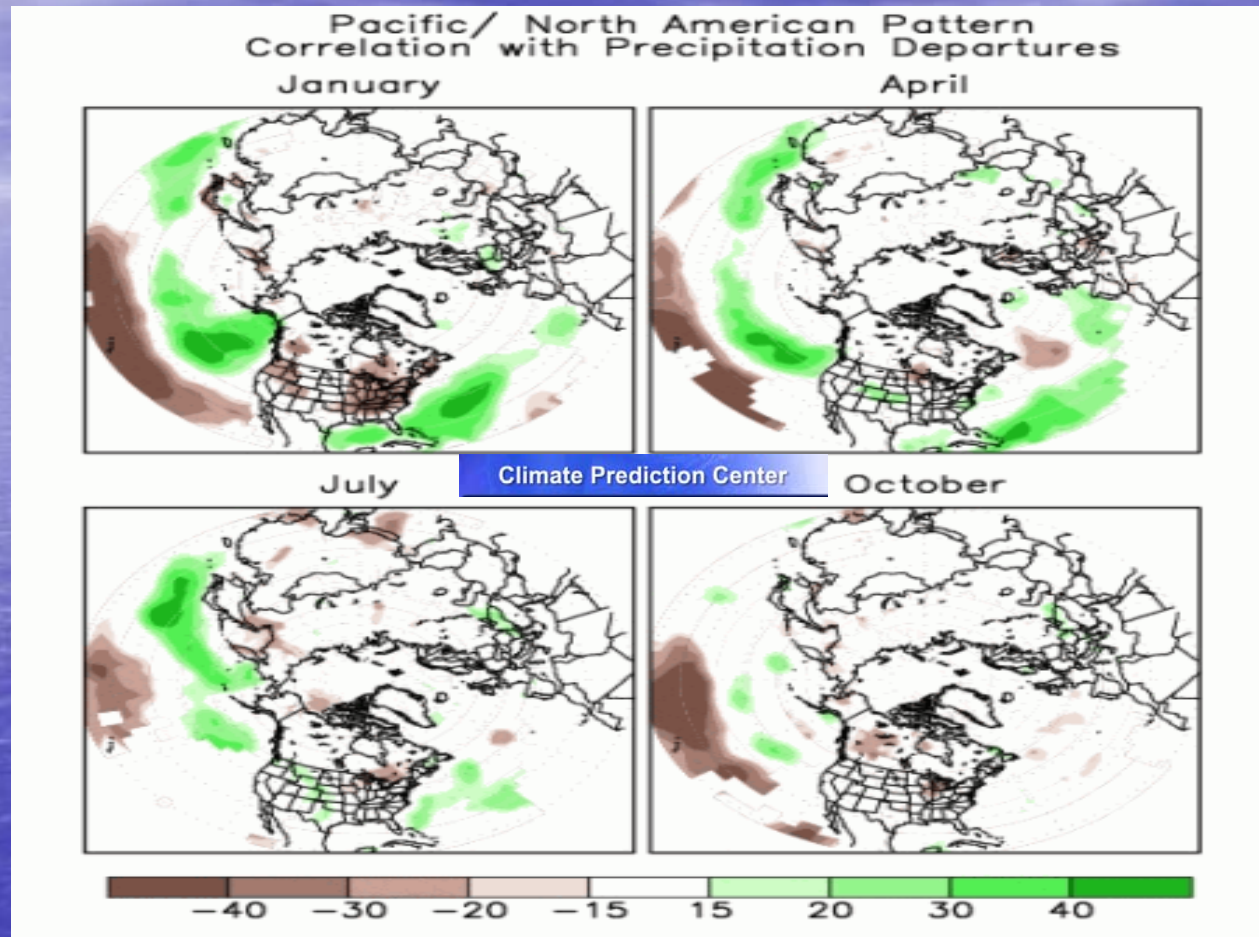


The Pacific/North American (PNA) Tele-connection

Winter hgt700 EOF2 10.7%

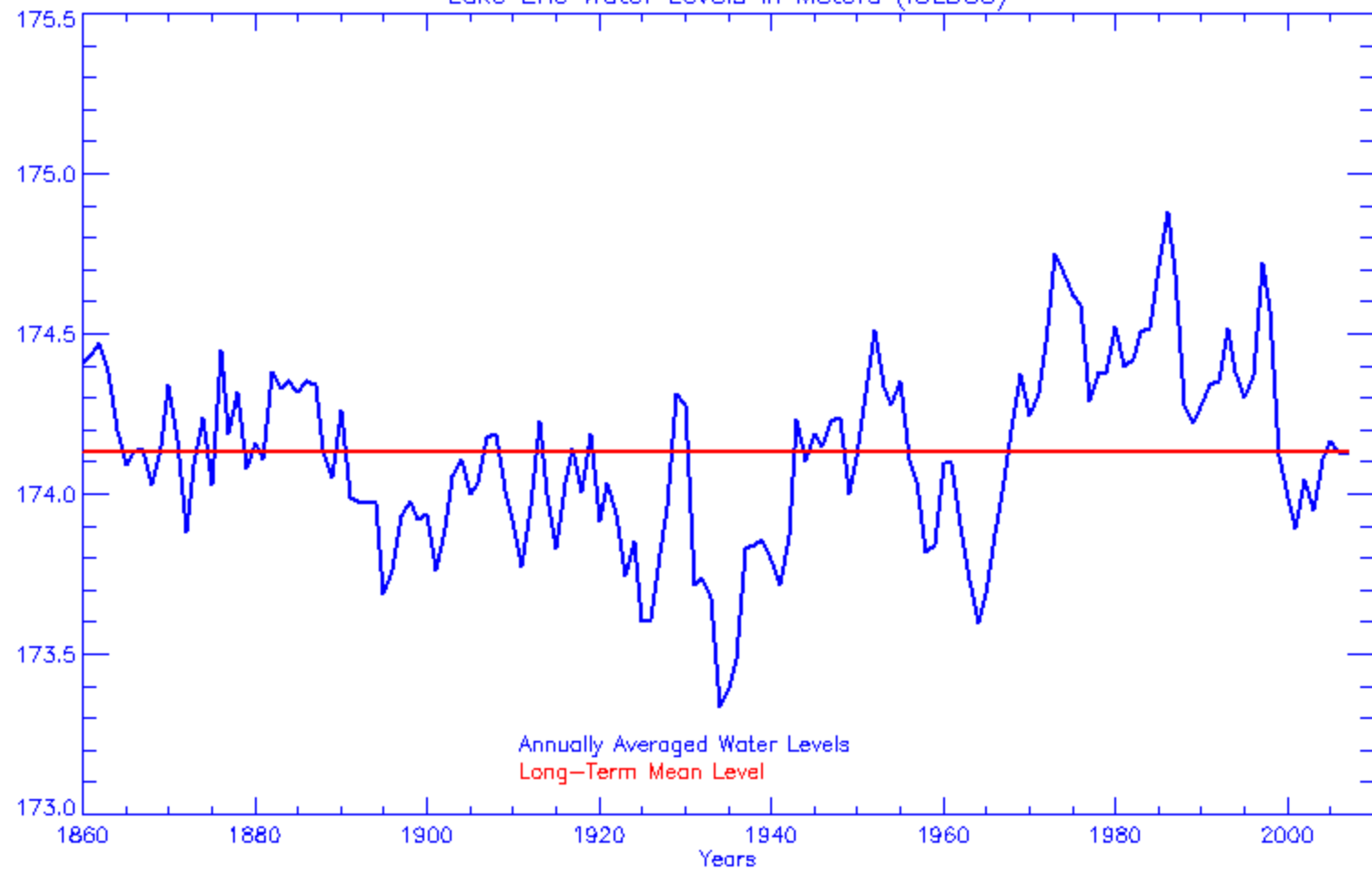


Under a warmed climate, there will be greater frequency of El Niño conditions

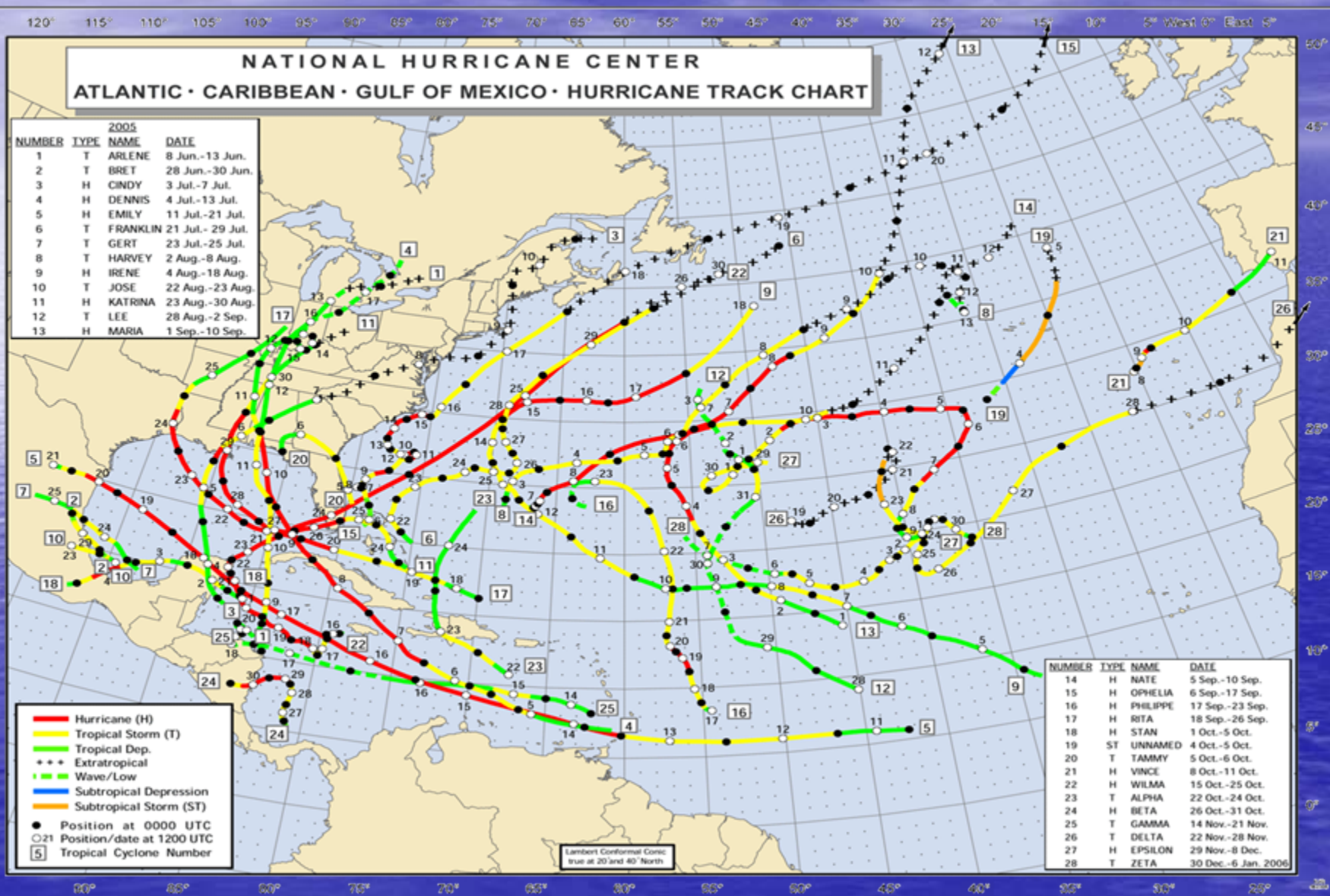


- Strong El Niño → Correlated with Warmer Winter Temperatures
- PNA → Below Average Precipitation Totals in the Winter
- PNA → Strongly Correlated with El Niño

Lake Erie Water Levels in Meters (IGLD85)



Additional Moisture to the Lower Lakes



Ohio Flooded due to remnants of Tropical Storm Erin; 22 August 2007



WTOL-TV Toledo—22 August 07; 4 – 9 inches of rain left roads, cars and basements flooded.



Residents hoped to return to their water-soaked homes Thursday after heavy downpours brought the city's deepest flood waters in nearly 100 years (MSNBC—Findlay Ohio)

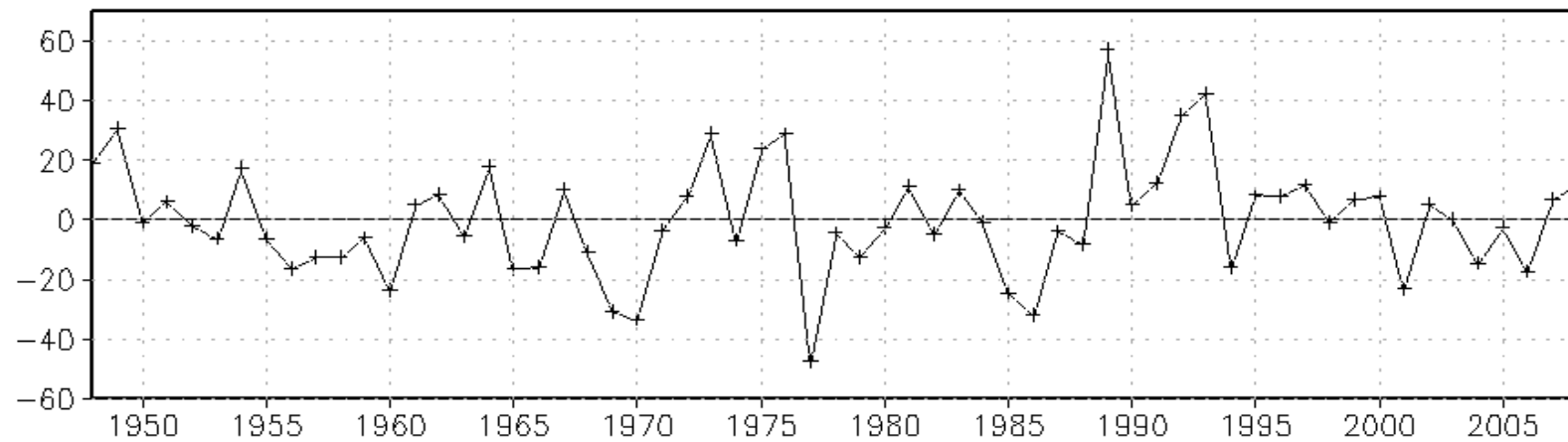
Thoughts...

- Decadal-to-centennial forecasts are needed
- Preliminary results connect Atlantic and Pacific Oceans to the Great Lakes
- The Lakes don't respond to climate as one system

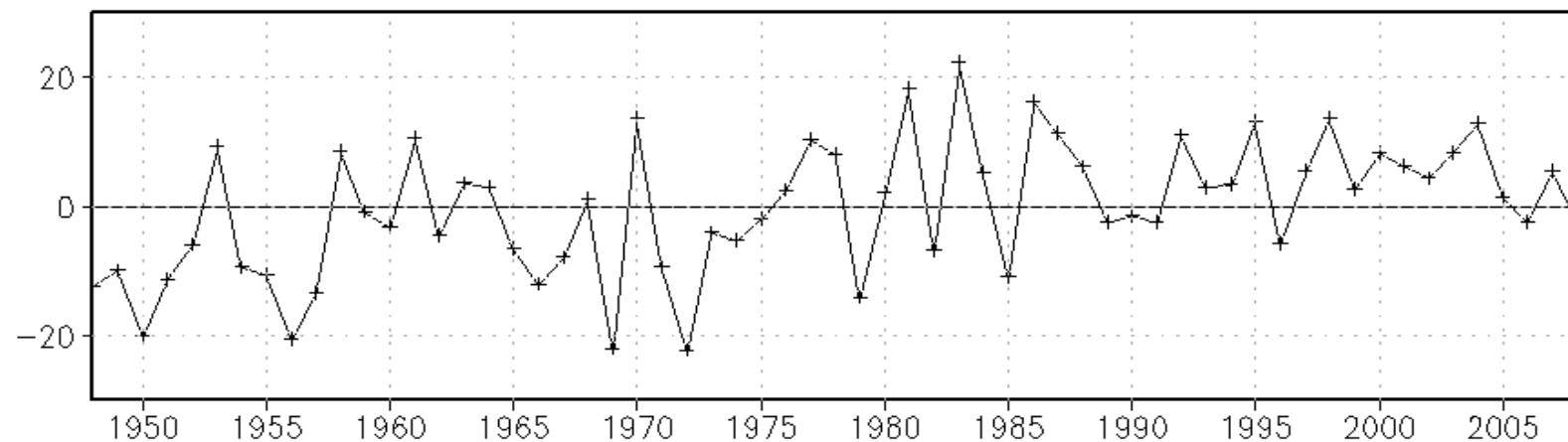
Questions?



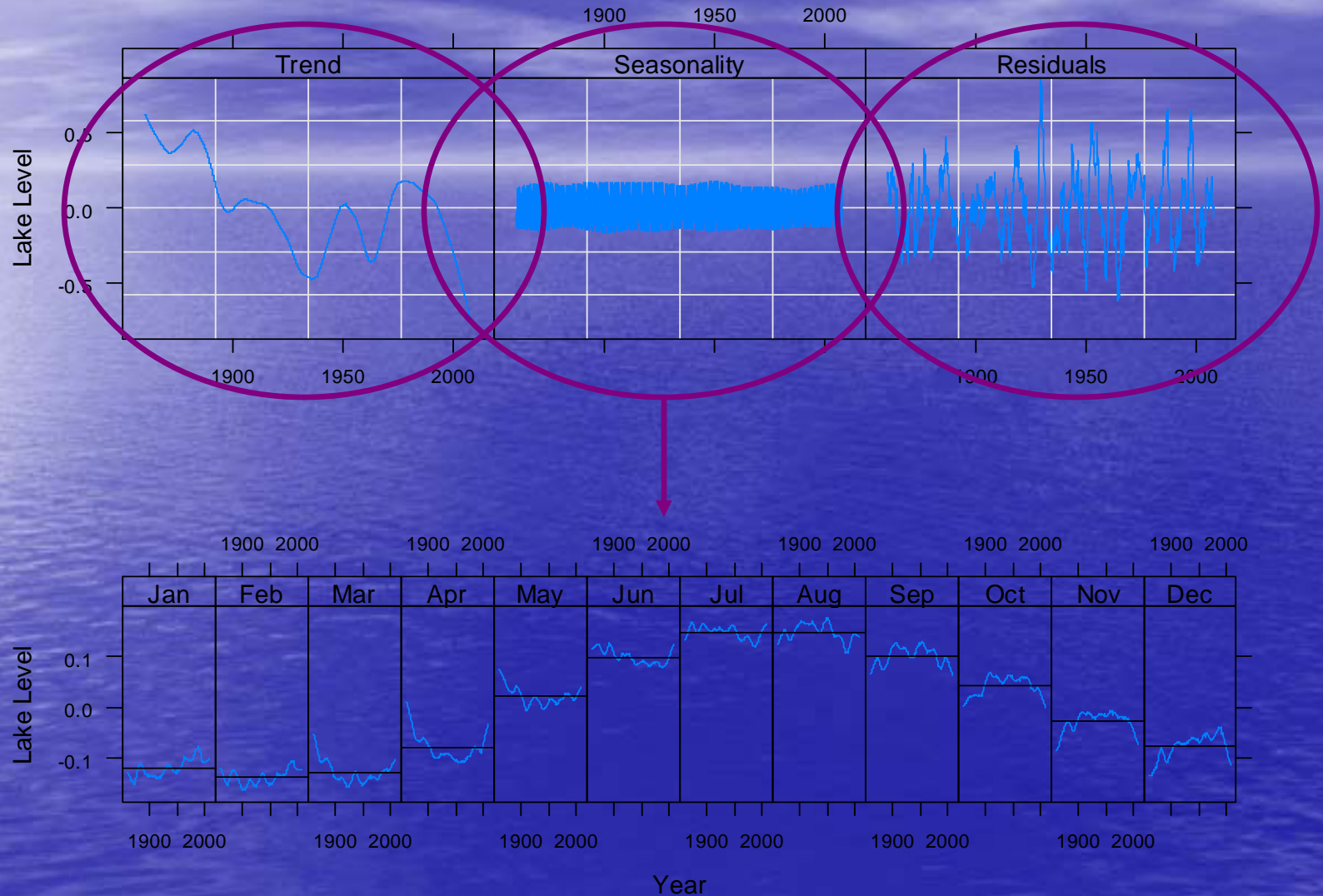
Winter hgt700 PC1



Winter hgt700 PC2

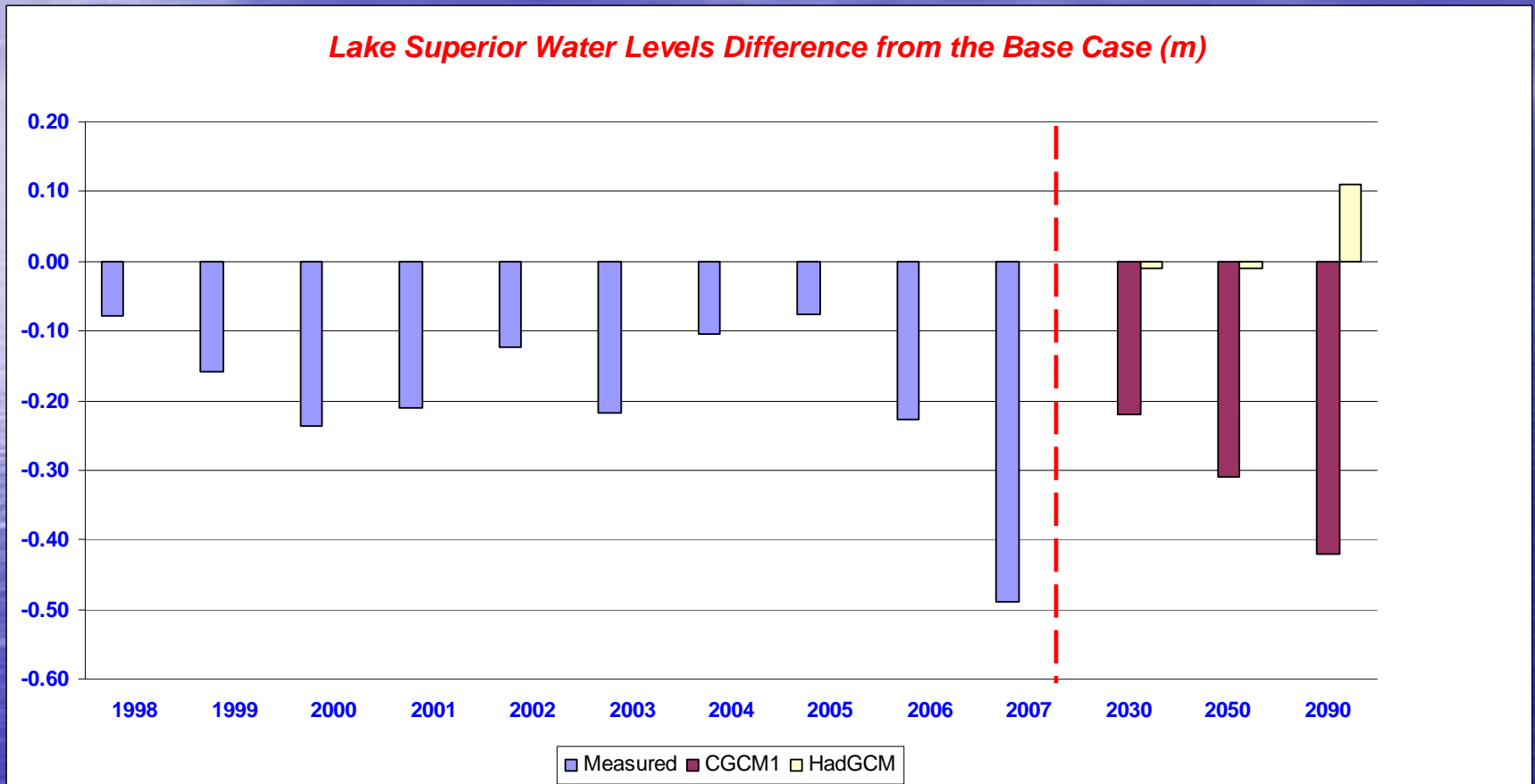


Seasonal Trend Decomposition using Loess (STL)



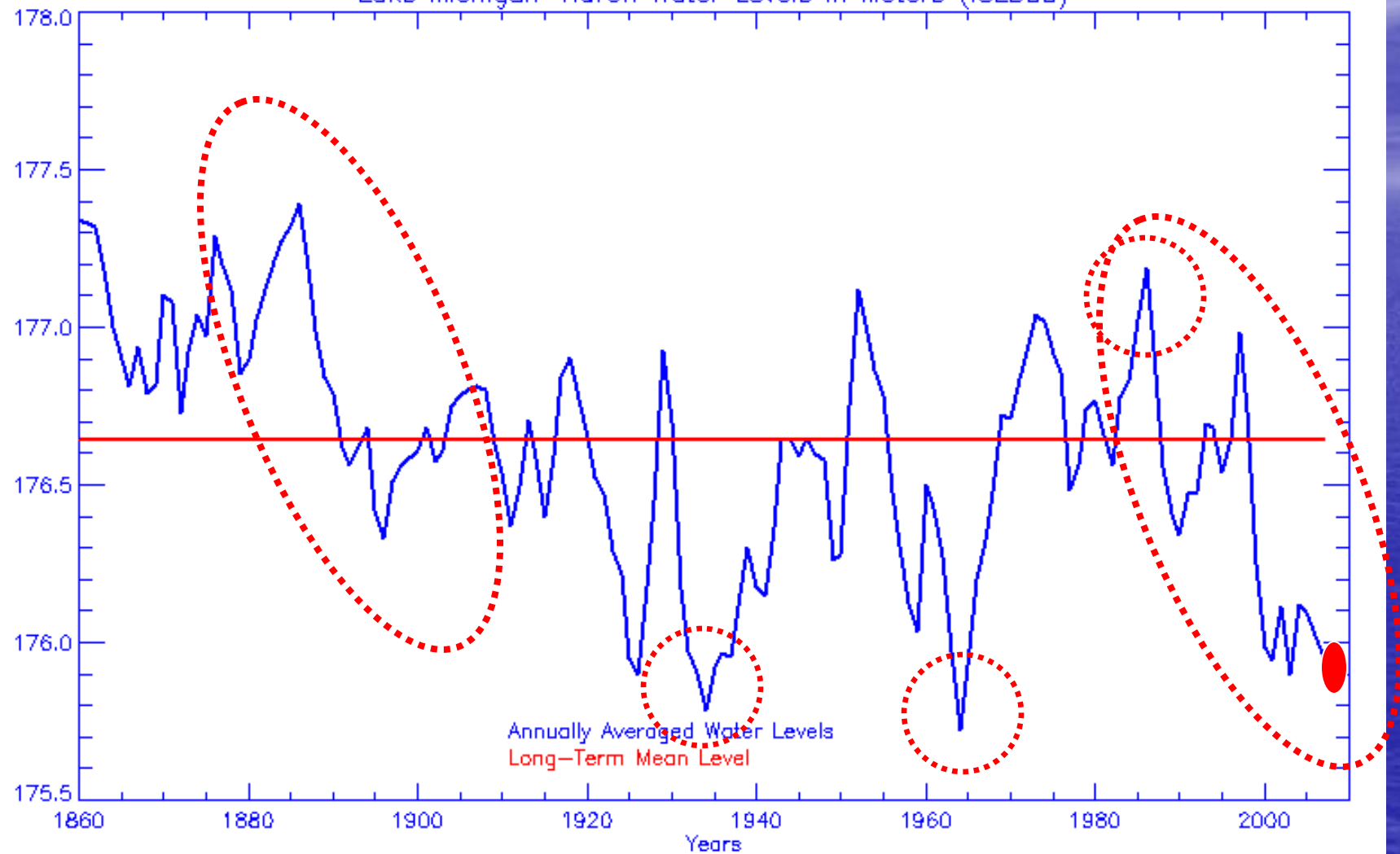
Detailed in "Visualizing Data" by W. S. Cleveland, Hobart Press, 1993

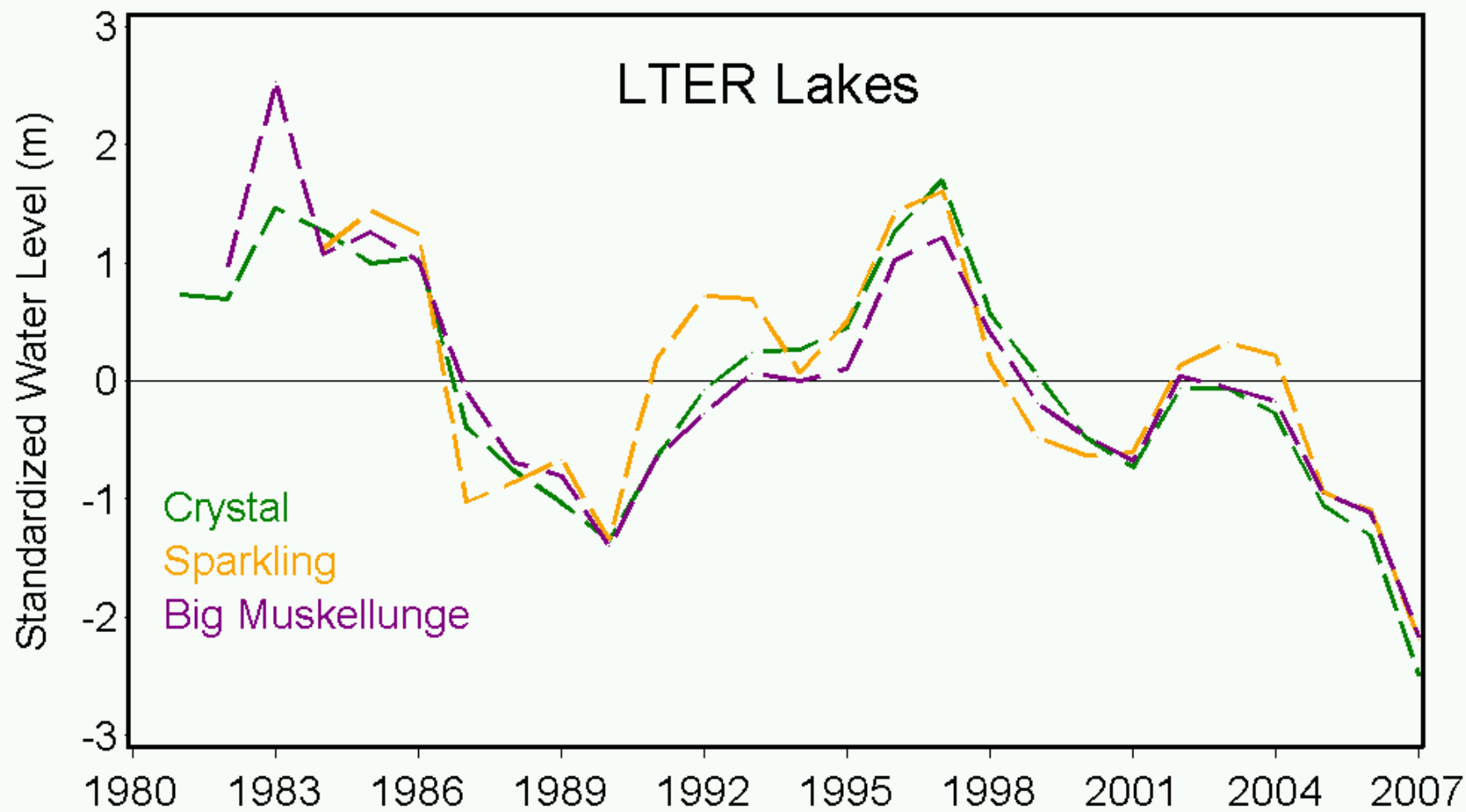
Climate Change Scenario

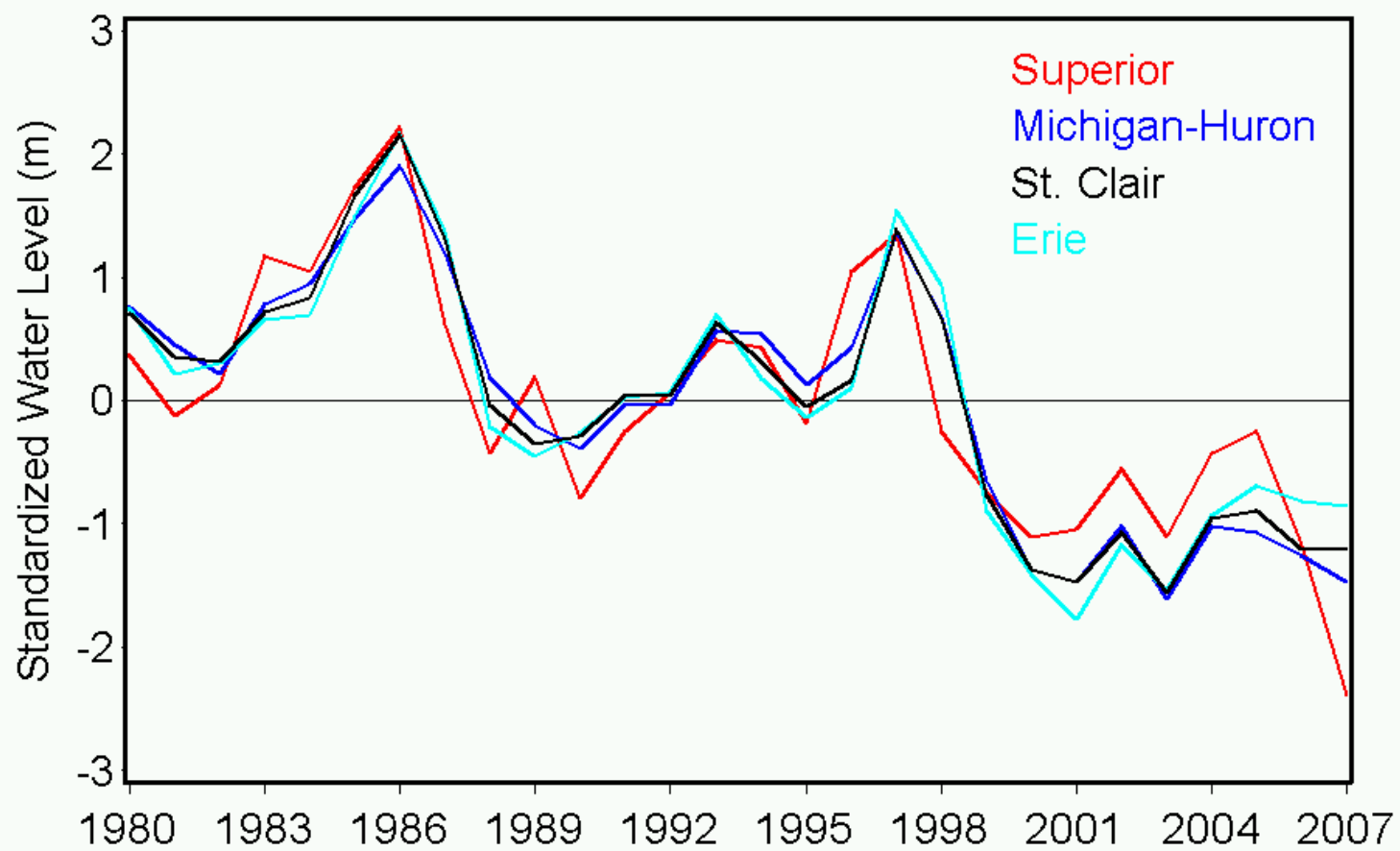


Lofgren, B.M., F.H. Quinn, A.H. Clites, R.A. Assel, A.J. Eberhardt and C.L. Luukkonen, 2002. Evaluation of Potential Impacts on Great lakes Water Resources Based on Climate Scenarios of Two GCMs. J. Great lakes Research. 28(4): 537-554.

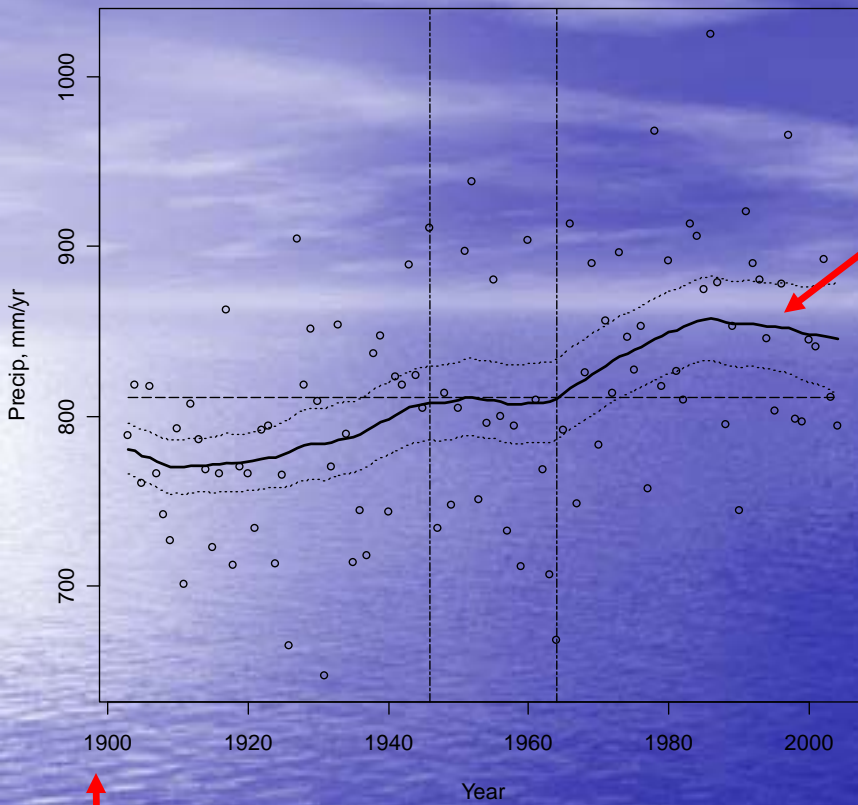
Lake Michigan–Huron Water Levels in Meters (IGLD85)





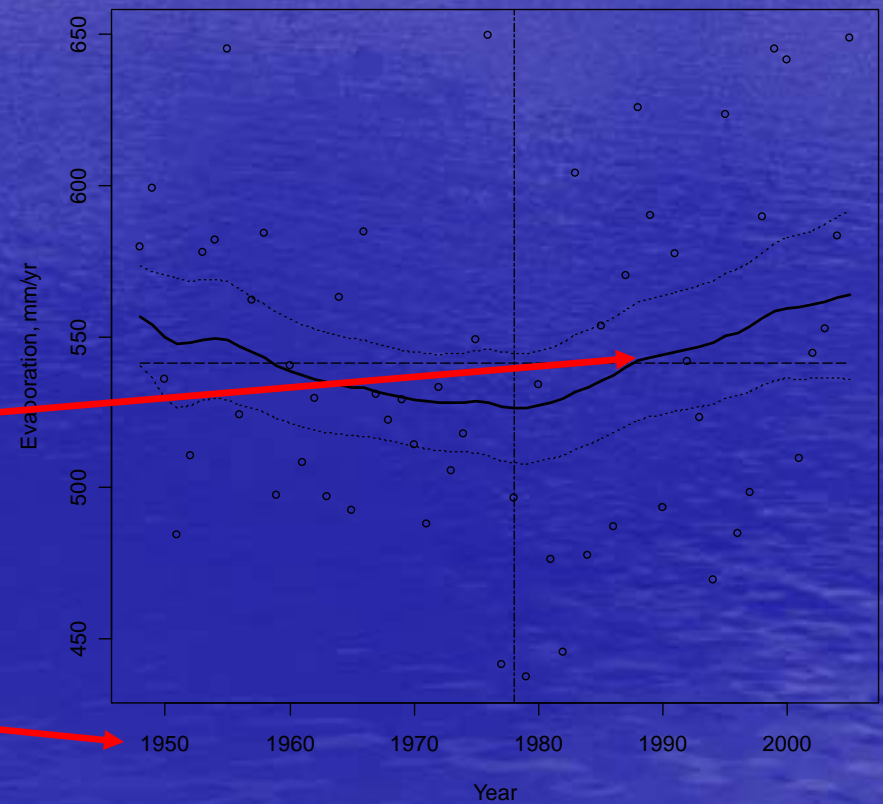


Lake Michigan Basin Precipitation
Model Fits



General precipitation increase
but recent decrease...

Lake Michigan Basin Evaporation
Model Fits

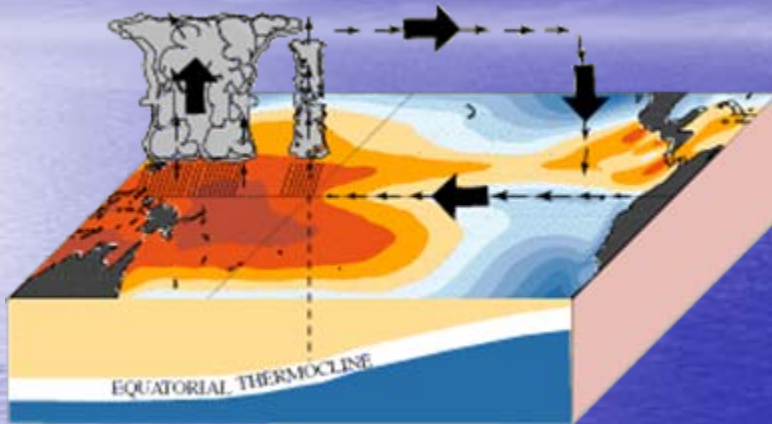


Recent evaporation increase

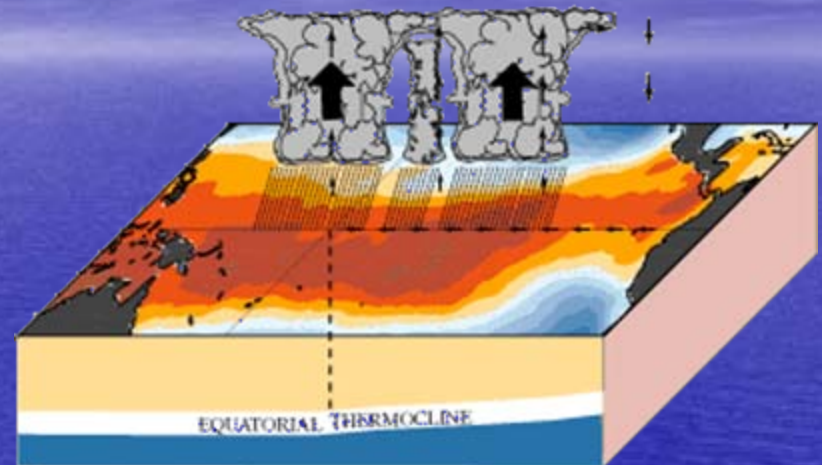
Periods of record differ

El Nino & La Nina

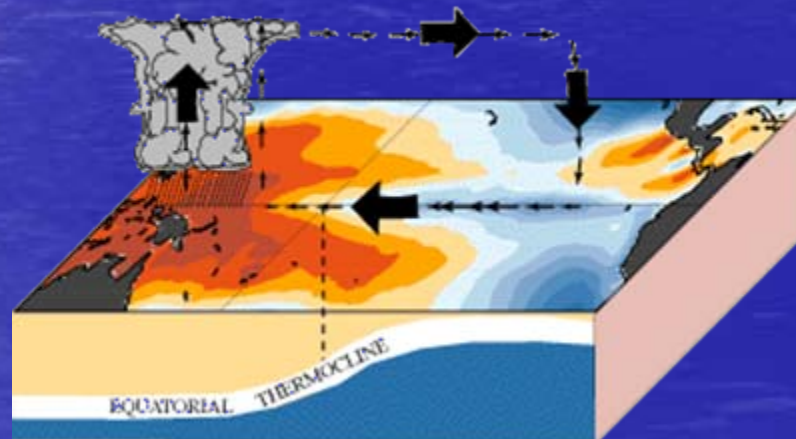
December - February Normal Conditions



December - February El Niño Conditions



December - February La Niña Conditions



Lake Superior Water Levels in Meters (IGLD85)

